Department of Energy
Savannah River Operations Office
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JUL - 8 2019

Ms. Susan B. Fulmer, P. G., Manager
Federal Remediation Section
Division of Site Assessment, Remediation and Revitalization
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, South Carolina 29201

Mr. Jon Richards
Acting Savannah River Site Remedial Project Manager
Superfund Division
U. S. Environmental Protection Agency, Region 4
61 Forsyth Street, SW
Atlanta, Georgia 30303

Dear Ms. Fulmer and Mr. Richards:

SUBJECT: Removal Action Design Plan (RADP) with Effectiveness Monitoring Plan (EMP) for the P-Area Groundwater (PAGW) Operable Unit (OU) (SRNS-RP-2019-00105, Revision 1, July 2019) (Redline Pages and Clean Copy) and Savannah River Site's Responses to the Regulatory Comments on the Revision 0 Document, SEMS Number: 81

The U.S. Department of Energy (DOE) is submitting the subject information for your review. The South Carolina Department of Health and Environmental Control (SCDHEC) approved the Revision 0 document on May 23, 2019 and the U. S. Environmental Protection Agency (EPA) provided comments on May 31, 2019. All comments have been addressed and incorporated into the Revision 1 document. Please review the enclosures and provide your approval within thirty (30) days of receipt. The effort and time that the SCDHEC and the EPA have given on the subject operable unit are greatly appreciated.

Questions from you or your staff may be directed to me at (803) 952-8365, or the DOE Program Manager, Mr. Philip Prater, at (803) 952-9333.

Sincerely,

Brian T. Hennessey
SRS Remedial Project Manager
Area Completion Project

IACD-19-170

Enclosures:
1. Removal Action Design Plan (RADP) with Effectiveness Monitoring Plan (EMP) for the P-Area Groundwater (PAGW) Operable Unit (OU) (SRNS-RP-2019-00105, Revision 1, July 2019) SEMS Number: 81 (Redline Pages and Clean Copy)
2. SRS Responses to United States Environmental Protection Agency Comments on the Removal Action Design Plan (RADP) with Effectiveness Monitoring Plan (EMP) for the P-Area Groundwater (PAGW) Operable Unit (OU) (SRNS-RP-2019-00105, Revision 0, April 2019) SEMS Number: 81

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Removal Action Design Plan (RADP) with Effectiveness Monitoring Plan (EMP) for the P-Area Groundwater (PAGW) Operable Unit (OU)

SEMS Number: 81

SRNS–RP–2019-00105

Revision ~~0~~1 Redline

~~April~~July 2019

SAVANNAH RIVER SITE • AIKEN, SOUTH CAROLINA

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued/End)*

SC	Steel Creek
SCDHEC	South Carolina Department of Health and Environmental Control
SEMS	Superfund Enterprise Management System
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
TCE	trichloroethylene
~~tonnes~~	~~metric ton~~
UAZ	Upper Aquifer Zone
μg/L	microgram per liter
UIC	Underground Injection Control
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture Forest Service
WMP	Waste Management Plan
ZVI	zero-valent iron

The PAGW OU encompasses the groundwater beneath P Area, northwest to SC, northeast toward PAR Pond and SRS Road F, and southeast to Meyers Branch and is established for the purposes of groundwater modeling. Groundwater over portions of the PAGW OU areal extent has been impacted by reactor and facility operations between 1954 and 1991. Groundwater plumes are present in the PAGW OU Upper Aquifer Zone (UAZ) and Lower Aquifer Zone (LAZ) of the Upper Three Runs Aquifer.

The nature and extent of contamination was investigated for the PAGW OU using groundwater monitoring wells, direct-push technology, and surface water samples (SRNS 2013). Groundwater contamination associated with chlorinated volatile organic compounds (cVOCs) is primarily exhibited in a narrow band north of the P-RBC and extends to the west to SC, where impact is known, and east towards an unnamed tributary to PAR Pond. The cVOC groundwater plumes can be described in three parts: 1) source area, 2) neck area, and 3) distal area (Figures 2 and 3). Maximum contaminant level (MCL) exceedances in groundwater occur over an area of ~17/21 acres for TCE in the UAZ/LAZ. Tetrachloroethylene (PCE) and cis-1,2-dichloroethylene (cis-DCE) plumes present in the UAZ and LAZ are contained within the TCE plume area as described and shown in the Sampling and Analysis Plan Addendum (SRNS 2018b). The source area represents most of the groundwater contamination and is centered north of the P-RBC within the P-Area facility area. The neck area represents the area where the cVOC groundwater plumes are controlled by a buried geologic feature thus creating a narrowing of the groundwater plumes and is located to the west just outside of the P-Area facility area. The distal area represents the area where the plumes are closest to SC. Table 1 lists the maximum reported concentrations for TCE, PCE, and cis-DCE in the UAZ and LAZ at the three areas during the fourth quarter sampling event in 2016 (SRNS 2018a). Surface water in SC is impacted by discharges of TCE contaminated groundwater above the MCL of 5-micrograms per liter (µg/L). The area of impact is localized to the upper section of the creek. Maximum TCE concentrations were observed at 28.3-µg/L in 2013. Recent (2018) measured TCE concentrations are 14.9-µg/L.

1.3 Regulatory Documentation

The United States Department of Energy (USDOE), US Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) have were much lower than in the UAZ and that the groundwater flow direction of the LAZ was much more northerly than what was expected (SRNS 2019a). Considering that the LAZ groundwater flow direction would lead to inefficient capture of the TCE plume by the ZVI-PRB proposed, and the TCE concentration data which showed approximately 95% of the TCE mass is present in the UAZ, focus was placed on constructing a ZVI-PRB to only target the UAZ TCE plume. Design and construction details for the final-design are provided in this RADP.

2.2 Design Details

The ZVI-PRB will be constructed using 22 ZVI injection wells (F1-F22) spaced ~3.7-meters (m) (12-feet [ft]) apart. The 12-ft spacing of the ZVI injection wells is based on the vendor's field experience from prior implementations and site-specific conditions to ensure complete coalescence of the ZVI-PRB. The ZVI-PRB will extend for a total of 80.5-linear meters (LM) (264-linear feet [LF]) in a "zig-zag" orientation, transecting the TCE plume in the UAZ (Figure 4). The ZVI-PRB will be one continuous permeable barrier comprised of four segments, Segment A through Segment D. Segment D consists of two sub-segments, Segment D_1 and Segment D_2, with different depth intervals. Figures 5 and 6 show cross-sections of the expansion casing construction, and details of each segment are provided in Table 2 and summarized below:

- Segment A will be 21.9-LM (72-LF) (F1-F6), oriented in a northeast to southwest alignment, installed from 13.7-m (45-ft) below ground surface (bgs) to 41.1-m (135-ft) bgs, and will have a cross-sectional area of ~602-square meters (m^2) (6,480-square feet [ft^2]).
- Segment B will be 25.6-LM (84-LF) (F7-F13), oriented in a northwest to southeast alignment, installed from 13.7-m (45-ft) bgs to 41.1-m (135-ft) bgs, and will have a cross-sectional area of ~702-m^2 (7,560-ft^2).
- Segment C will be 11.0-LM (36-LF) (F14-F16), oriented in a northeast to southwest alignment, installed from 13.7-m (45-ft) bgs to 41.1-m (135-ft) bgs, and will have a cross-sectional area of ~301-m^2 (3,240-ft^2).
- Segment D_1 will be 7.32-LM (24-LF) (F17-F18), oriented in a north-northwest to south-southeast alignment, installed from 13.7-m (45-ft) bgs to 41.1-m (135-ft) bgs, and will have a cross-sectional area of ~201-m^2 (2,160-ft^2).

- Segment D_2 will be 14.6-LM (48-LF) (F19-F22), oriented in a north-northwest to south-southeast alignment, installed from 13.7-m (45-ft) bgs to 36.6-m (120-ft) bgs, and will have a cross-sectional area of ~334-m^2 (3,600-ft^2).

Active resistivity mapping will be used to ensure complete coalescence and accurate construction of the ZVI-PRB. During injection, the ZVI mixture will be electrically energized with a low-voltage 100-Hertz (Hz) signal. Downhole resistivity receivers will be monitored to record the in-phase induced voltage by the propagating inclusions. From monitoring the carrier fluid induced voltages and utilizing an incremental inverse integral model, the carrier fluid geometry can be quantified and displayed during the installation process (Figure 7). Resistivity strings will be installed 7.3-m (24-ft) from the ZVI-PRB and will be installed using cone penetrometer technology (CPT). Resistivity strings are contained in clear braided polyvinyl chloride (PVC) tubing with spiral fabric reinforcement (3/4-inch [in.] inside diameter minimum). Each resistivity receiver is located ~1.5-m (5-ft) apart along the string and attached to individual wires. A total of 23 resistivity strings will be installed, with 19 resistivity strings containing 19 receivers from ~13.7- to 41.1-m (45- to 135-ft) bgs and the remaining 4 resistivity strings will consist of 16 receivers from ~13.7- to 36.6-m (45- to 120-ft) bgs. Figures 5 and 6 show the cross-sections of the resistivity strings for the ZVI-PRB.

Approximately 627-metric tons (tonnes) (691-tons) (~689-metric tonstonnes [760-tons] with 10% waste) of ZVI will be required to construct the proposed ZVI-PRB. This is determined based on a total ZVI-PRB surface area of 2,140-m^2 (23,040-ft^2), a thickness of 10-centimeter (cm) (4-in.), and an average ZVI density of 2,883-kilogram per cubic meter (180-pounds per cubic foot). The ZVI will be injected into the subsurface through the 22 injection wells. Based on subcontractor field experience, Tthe general rate of injection is expected to be between 9.07-metric tonstonnes/day (10-tons/day) and 16.3-metric tonstonnes/day (18-tons/day). Prior to injection, the ZVI filings will be mixed with hydroxypropylguar (HPG) to produce an extremely viscous mixture that suspends the ZVI throughout. This mixture is then forced into the subsurface through 3.1-m (10-ft) long expansion casings oriented along the ZVI-PRB trace. The viscous mixture is able to fracture the subsurface and fill the void. After a few hours of injection, the HPG will degrade into sugars and

Numerous ZVI-PRB design cases were evaluated for the ZVI-PRB alignment as shown in Figure 4. The ZVI reactive barrier system performance was evaluated based on the ability of the system to reduce TCE concentrations in groundwater by 90% of the design influent concentration even though the design criteria is to reduce TCE mass flux by ~80%.

The results of the probabilistic analysis performed for design cases with properties representing the UAZ, indicate that a 1.5-inch average iron-effective thickness PRB is sufficient to bring cVOCs in site groundwater to 90% less than the design influent concentrations based on simulated effluent concentrations. An additional engineering factor of safety of 2.67 would provide a 4-inch iron-effective-thickness and would ensure that the desired concentration reductions are met in the effluent as well as account for potential precipitation/clogging of the iron with increased PRB longevity.

2.5.6 *Iron Soil Analysis*

Soil samples collected during the PDI were sent to CSRA Testing & Engineering, Inc. in Augusta Georgia for sieve analysis and hydrometer analysis. The grain size gradation coefficients of the iron and soil were compared to ensure the iron particles do not migrate into the site soils. Based on this evaluation, a blend of Peerless 14D (-12/+100 mesh) and coarser material from Peerless 850 (-8/+50) is suitable for injection resulting in a blend of -8/+100 mesh (0.15 to 2.36 mm). The grain size contrast between the iron and soil indicates that the iron is predominantly more conductive than the native soil.

2.6 Drawings

The figures and tables contained in this document serve as the design drawings for this project. No additional drawings are planned for this project. The drawings provided in this document, in conjunction with the construction requirements in Section 4.0, provide the basic requirements for implementation of the removal action design for the PAGW OU.

2.7 Surveys

Prior to the design phase of the removal action, the proposed PRB area was surveyed and site drawings were used to verify that no subsurface interferences would impact the ZVI-PRB. In

120-ft) bgs, a steel riser from 32.0- to 33.5-m (105- to 110-ft) bgs, an expansion casing from 29.0- to 32.0-m (95- to 105-ft) bgs, etc. Following the final expansion casing, steel riser will extend to the ground surface, with connections made using tack welding. While the injection wells are being constructed, the 23 resistivity strings will be installed 7.3-m (24-ft) offset from the ZVI-PRB. This spacing is based on the distance required for active resistivity mapping of the ZVI injections to monitor complete coalescence based on field experience and site-specific conditions. Resistivity strings will be installed using CPT to emplace braided PVC tubing that will hold the individual resistivity wires and stainless-steel collars. Figures 5 and 6 show cross-sections of the injection wells and resistivity strings.

Based on the design, ~627-metric tons~~tonnes~~ (691-tons) (~689-metric tons~~tonnes~~ [760-tons] allowing for 10% wash out) of ZVI will be emplaced using the 22 injection wells, set ~3.7-m (12-ft) apart, centered along the ZVI-PRB alignment (Figure 4). ZVI filings will be emplaced using a carrier fluid that ensures the consistency and viscosity needed to propagate the inclusions through the subsurface. The carrier fluid consists of HPG, ZVI, a cross-linker, and an enzyme. Table 5 provides the composition of the carrier fluid. The HPG will be pre-mixed with water in a 3,000-gallon mixing tank utilizing a venturi blender and then fed into a 757-liter (200-gallon) mixing/blending tank along with the ZVI filings. While in the mix unit, the HPG will be kept in a water soluble (uncross-linked) state with the ZVI filings suspended evenly throughout. The mixture will then be fed to the injection pump and mixed in-line with a cross-linker and enzyme instantly, causing the mixture to become cross-linked, water insoluble, and extremely viscous. This viscous mixture of HPG and ZVI filings will then be pumped into an expansion casing causing the casing to dilate, creating a controlled vertical inclusion pathway at the required azimuth orientation and depth. The pathway of each inclusion will be guided by pore pressure relief between casings, thus ensuring vertical and lateral coalescence of the ZVI filings between each expansion casing. The ZVI-PRB will be constructed in multiple sections using the individual expansion casings separated by packers. The ZVI-PRB will be constructed from the bottom at each injection well location. Because the void created by each ZVI inclusions will have a thickness less than the design thickness, ~~In order to construct the ZVI-PRB as designed,~~ multiple injections will be made in each injection well until the design thickness (10.2-cm [4-in.]) is reached~~,~~ or all ZVI has been injected. Expansion casings will be washed out using a water jet before each subsequent injection. Following injection of the ZVI, the enzyme causes the gel to biodegrade into water and sugars, leaving a permeable iron reactive treatment zone.

Eight UAZ monitoring wells (PRW001DU, PRW001DL, PRW002DU, PRW002DL, PRW003DU, PRW003DL, PRW004DU, PRW004DL) within the ZVI-PRB area have the potential to cause short circuiting during the ZVI injections. Short circuiting during the injection process could result in a ZVI-PRB that is not continuous and/or lead to surfacing of ZVI through the monitoring wells. To address this potential issue, the monitoring wells will be filled with sand and capped prior to ZVI injection. Following completion of the ZVI-PRB, the eight monitoring wells will be airlifted to remove the sand and redeveloped.

The ZVI-PRB installation will be monitored to determine the geometrical extent of the barrier, thus ensuring it is installed as designed using active resistivity mapping. A general layout of the resistivity monitoring system to be used during installation of the ZVI-PRB is shown on Figure 7. During injection, the ZVI-gel mixture will be electrically energized with a low voltage 100-Hz signal. Twenty-three downhole resistivity receivers will be monitored to record the in phase induced voltage by the propagating inclusion (See Figure 7). From monitoring the carrier fluid induced voltages and utilizing an incremental inverse integral model, the inclusion fluid geometry can be quantified and displayed during the installation process to provide a high-resolution image of the ZVI-PRB geometry.

Following injection of ZVI and construction of the ZVI-PRB, four injection wells will be retrofitted to monitoring wells. The four injection wells of interest (F5, F11, F17, and F21) will be washed out to depth using a water jet to remove iron filings. The installed one-inch diameter monitoring wells will be comprised of a well cap, a 6.10-m (20-ft), 0.0254-cm (0.010-in.) slot screen, and riser piper to grade. Since the proposed wells are being installed in-wall, the wells will not be constructed by typical installation methods. After the injection wells are flushed out and the well set, the annulus will be backfilled with ZVI. This will ensure continuity of the PRB and minimize impact on the long-term performance of the PRB. A cross-section of the in-wall monitoring wells is provided in Figure 16. The monitoring well details and EMP are described in more detail in Section 5.1.

4.4 Waste Disposal and Transport

During installation of the ZVI-PRB, wastes that will be generated include:

- Typical drillings waste;
- Washout water from the expansion casings consisting of HPG, enzyme, cross-linker, and treated groundwater;
- Washout ZVI from expansion casings; and
- Typical job control waste.

Waste management (handling, disposal, and transportation of wastes) will meet the requirements of applicable SRS manuals and procedures (i.e., SRS C1 Procedure Manual, *Environmental Compliance and Area Completion Projects Administrative Procedures*, [SRS 2014a], SRS 1S Procedure Manual, *SRS Radioactive Waste Requirements Manual* [SRS 2014b], SRS 3Q Procedure Manual, *Environmental Compliance Manual* [SRS 2015a], etc.) and the project-specific WMP. Based on process knowledge ~~and TCLP results provided by the ZVI vendor~~of the ZVI-PRB construction along with the iron filing safety data sheet provided by the subcontractor, no hazardous waste will be generated. Any job control waste (non-hazardous) will be disposed of as sanitary waste by the subcontractor. Disposition of drilling fluids and byproducts from the ZVI injection process are summarized below.

During the installation of the 22 injection wells, drilling fluids will be discharged to the ground within the area of contamination (AOC) in accordance with the project-specific WMP and the approved SRS Investigative-Derived Waste Management Plan (WSRC 2013). Installation of the 23 resistivity strings will be via CPT or sonic drilling methods. Although no drilling waste associated with the installation of the resistivity wells is expected, resistivity string drilling waste will be handled in the same way as the injection well drilling waste. Any water generated during decontamination of the CPT rods will be discharged to the ground within the AOC in accordance with the project-specific WMP and the approved SRS Investigative-Derived Waste (IDW) Management Plan.

Washout fluid generated prior to injection of the ZVI in each of the wells will be comprised of groundwater, carrier fluid mix, and iron. This liquid will be stored in a roll-off container. The

the subcontractor's response to the emergency, including arrangements with onsite security, fire department, medical facility, and emergency response teams to coordinate emergency services.

5.0 POST CONSTRUCTION

5.1 Effectiveness Monitoring Plan

Three existing upgradient well clusters (PRW001, PRW003, and P003) and three existing downgradient well clusters (PRW002, PRW004, P002) will be sampled prior to the start of the NTC removal action to establish a baseline, which included all analytes in Table 7. Three proposed downgradient well clusters (PRW005, PRW006, and PRW007), four proposed in-wall monitoring wells (PIW001D, PIW002D, PIW003D, and PIW004D), and the existing well clusters (Figure 17) will be used to monitor the PAGW OU treatment barrier effectiveness. The initial sampling event for the three proposed downgradient monitoring well clusters will include all analytes in order to establish a baseline. Station IDs, coordinates, and screen depths are provided in Table 6. The purpose of the in-wall monitoring is to provide rapid evidence of the ZVI effectiveness in destroying VOCs. In addition, the geochemical analyses proposed for in-wall monitoring wells will allow for evaluation of the reactions occurring between the contaminated groundwater and ZVI on the ZVI-PRB longevity related to possible precipitation, mineralization, and biofouling. The upgradient and downgradient monitoring well clusters will be analyzed for VOCs to assess the overall reduction in VOC mass in the plume over time. Because the downgradient monitoring wells are located in contaminated aquifer sediments it may be many years before evidence of VOC reduction is observed. The in-wall monitoring wells will be sampled bi-monthly for the first 3-months, monthly for the second 3-months, and quarterly for the next 4.5-years. The wells within the ZVI-PRB area will be sampled quarterly for the entire 5-years. The one well cluster farthest from the ZVI-PRB will be sampled annually for the entire 5-years. Table 7 provides the preparation/analytical methods for each analyte. Table 8 and Figure 18 present the sampling frequency for each well and Table 8 indicates which analytes will be analyzed.

The effects of the PAGW OU ZVI-PRB will be reported annually in the ZVI-PRB Effectiveness Monitoring Report.

6.0 REFERENCES

SRNS, 2008. RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report with Baseline Risk Assessment and Corrective Measures Study/Feasibility Study (CMS/FS) for the P-Area Operable Unit (U), WSRC-RP-2007-4032, Revision 1.2, December 2008, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2012a. Performance Evaluation Report for the P-Area Operable Unit Potential Source Areas 3A and 3B Subunits, SRNS-RP-2012-00335, Revision 1, April 2013, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2012b. Post-Construction Report (PCR) for the P-Area Operable Unit (U), SRNS-RP-2011-01582, Revision 1, July 2012, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2013. Sampling and Analysis Plan for the P-Area Groundwater Operable Unit (U), SRNS-RP-2011-01284, Revision 1, September 2013, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2018a. Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis for Trichloroethylene Plumes Discharging to Steel Creek in P-Area Groundwater Operable Unit (NBN) (U), SRNS-RP-2017-00372, Rev 1, March 2018, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2018b. Sampling and Analysis Plan Addendum for the P-Area Groundwater Operable Unit (U), SRNS-RP-2018-00261, Rev 1, August 2018, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2019a. Permeable Reactive Barrier Removal Action Design Review – P-Area Reactor Groundwater Operable Unit, ERD-EN-2019-0011, April 2019, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRNS, 2019b. Underground Injection Control Permit Application for the Permeable Reactive Barrier in the P-Area Groundwater Operable Unit (U), SRNS-RP-2018-01144, Rev 0, March 2019, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

SRS, 2014a. SRS Procedure Manual C1, Environmental Compliance and Area Completion Projects Administrative Procedures, Savannah River Site, Aiken, SC.

SRS, 2014b. SRS Procedure Manual 1S, SRS Radioactive Waste Requirements Manual, Savannah River Site, Aiken, SC.

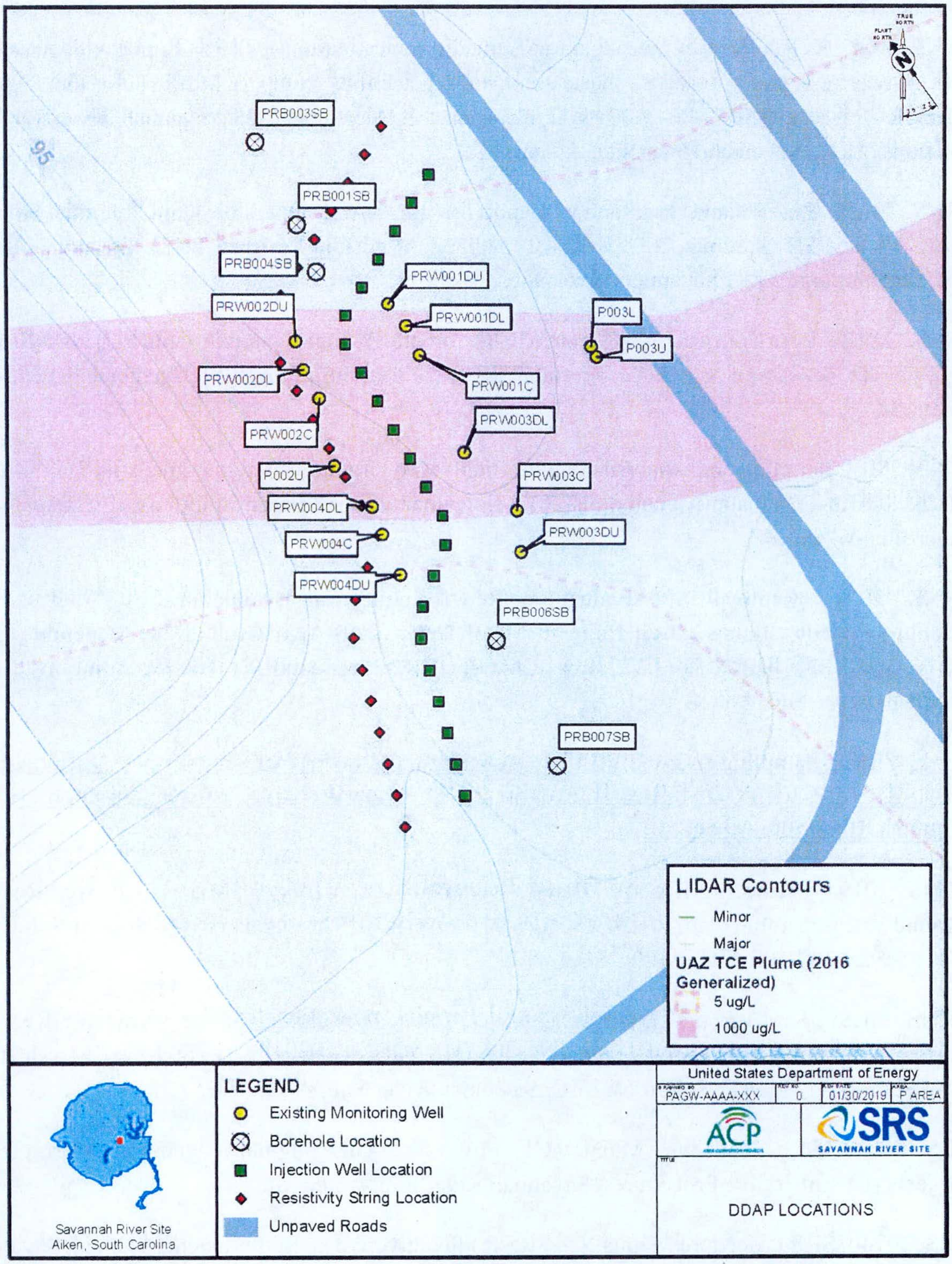


Figure 9. Design Data Acquisition Plan Locations

Comments Received May 31, 2019

GENERAL COMMENTS

1. Insufficient information is provided regarding several design details. For example,

   a. Section 2.2 (Design Details) indicates that the spacing between the zero-valent iron (ZVI) injection wells (F1-F22) is approximately 12 feet apart; however, information to support this radius of influence (ROI) is not provided and/or referenced.

Revise the Removal Action Design Plan (RADP) to provide information which supports the design details presented.

Response: Agree

The spacing between zero-valent iron (ZVI) injection wells (F1-F22) was determined by the subcontractor to ensure complete coalescence of the ZVI permeable reactive barrier (PRB) based on field experience and site-specific conditions. The subcontractor relied on knowledge of the patented vertical inclusion propagation (VIP) method to determine injection well spacing and field experience from installation of ZVI-PRBs at other sites. For depths greater than 50 feet, typical expansion casing spacing is 15 to 18 feet. The spacing of 12 feet at the PAGW OU was conservatively chosen based on the site-specific geology described in Section 2.5.1.

The first paragraph in Section 2.2 Design Details will be revised to add additional details as follows:

"The ZVI-PRB will be constructed using 22 ZVI injection wells (F1-F22) spaced ~ 3.7 meters (m) (12-feet [ft]) apart. The 12-ft spacing of the ZVI injection wells is based on the vendor's field experience from prior implementations and site-specific conditions to ensure complete coalescence of the ZVI-PRB. The ZVI-PRB will extend...."

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

1. Insufficient information is provided regarding several design details. For example,

   b. Section 2.2 indicates that the proposed ZVI permeable active barrier (PRB) will be 4 inches thick; however, information to support this thickness is not provided and/or referenced.

Revise the Removal Action Design Plan (RADP) to provide information which supports the design details presented.

Response: Clarification

As discussed in Section 2.5.5, the thickness of the PRB is based on design modeling that indicated a 1.5-inch thickness is sufficient to bring cVOCs in groundwater to 90% less than the design influent concentrations based on simulated effluent concentrations. An additional engineering factor of safety of 2.67 would provide a 4-inch iron-effective-thickness and would ensure that the desired

concentration reductions are met in the effluent as well as account for potential precipitation/clogging of the iron with increased PRB longevity. During injection of the ZVI, active resistivity mapping (Section 4.1) will be used to ensure complete and equal coalescence of the section being injected. By using the resistivity mapping and monitoring the volume of ZVI that is injected, design performance requirements for PRB emplacement are achieved. No change to the document is proposed.

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

1. Insufficient information is provided regarding several design details. For example,

   c. Section 2.2 indicates that the rate of injection is expected to be expected 10 tons per day and 18 tons per day yet information to support these rates of injection are not provided and/or referenced.

Revise the Removal Action Design Plan (RADP) to provide information which supports the design details presented.

Response: Agree

General injection rates were estimated by the subcontractor based on field experience from installation of ZVI-PRBs at other sites. For clarity, the third paragraph in Section 2.2 will be revised as follows:

"The ZVI will be injected into the subsurface through the 22 injection wells. <u>Based on subcontractor field experience,</u> ~~T~~the <u>general</u> rate of injection is expected to be between 9.07-<u>metric tons</u>~~tonnes~~/day (10-tons/day) and 16.3-<u>metric tons</u>~~tonnes~~/day (18-tons/day). Prior to injection..."

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

1. Insufficient information is provided regarding several design details. For example,

   d. Section 4.1 (Construction Strategy) indicates that the resistivity strings will be installed at a 24-foot offset from the ZVI-PRB; however, information to support this offset distance are not provided and/or referenced.

Revise the Removal Action Design Plan (RADP) to provide information which supports the design details presented.

Response: Agree

The resistivity string offset of 24 feet from the ZVI-PRB was determined by the subcontractor to be within the range required for active resistivity mapping of the ZVI injections to monitor complete coalescence based on field experience and site-specific conditions. For clarity, the first paragraph in Section 4.1 will be revised as follows:

Comments Received May 31, 2019

"While the injection wells are being constructed, the 23 resistivity strings will be installed 7.3-m (24-ft) offset from the ZVI-PRB. This spacing is based on the distance required for active resistivity mapping of the ZVI injections to monitor complete coalescence based on field experience and site-specific conditions. Resistivity strings will be installed using CPT…".

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

2. Section 4.1 (Construction Strategy) states, "In order to construct the ZVI-PRB as designed, multiple injections will be made in each injection well until the design thickness (10.2-cm [4-in.]) is reached, or all ZVI has been injected;" however, information regarding the additional injections (e.g., schedule, sequence) are not provided and/or referenced. In addition, information regarding how surfacing/daylighting of ZVI will be prevented and addressed, should it occur, are not provided and/or referenced. Revise the RADP to provide information regarding the additional injections and how surfacing/daylighting of ZVI will be prevented and addressed.

Response: Agree

The subcontractor will inject ZVI through the expansion casings at each location, starting from the lowest panel and working from the bottom. To achieve the design thickness in each panel, a fracture is initiated by the pressure of the injected ZVI. The fractures produced in this method are less than four (4) inches thick and the process is repeated until the design thickness is reached.

Eight UAZ monitoring wells within the ZVI-PRB area have the potential to cause short circuiting during ZVI injection, which could result in a ZVI-PRB that is not continuous and/or lead to surfacing of ZVI. To address this potential issue, the monitoring wells will be filled with sand and capped prior to ZVI injection. Following completion of the ZVI-PRB, the eight monitoring wells will be airlifted to remove the sand and redeveloped.

In order to clarify the injection procedure and address surfacing/daylighting, the second paragraph in Section 4.1 will be revised as follows:

"… coalescence of the ZVI filings between each expansion casing. The ZVI-PRB will be constructed in multiple sections using the individual expansion casings separated by packers. The ZVI-PRB will be constructed from the bottom at each injection well location. Because the void created by each ZVI inclusion will have a thickness less than the design thickness, ~~In order to construct the ZVI-PRB as designed,~~ multiple injections will be made in each injection well until the design thickness (10.2-cm [4-in.]) is reached~~,~~ or all ZVI has been injected. Expansion casings will be washed out using a water jet before each subsequent injection. Following injection of the ZVI, the enzyme causes the gel to biodegrade into water and sugars, leaving a permeable iron reactive treatment zone.

Eight UAZ monitoring wells (PRW001DU, PRW001DL, PRW002DU, PRW002DL, PRW003DU, PRW003DL, PRW004DU, PRW004DL) within the ZVI-PRB area have the potential to cause short circuiting during ZVI injection. Short circuiting during the injection process could result in a ZVI-PRB that is not continuous and/or lead to surfacing of ZVI through the monitoring wells. To address this potential issue, the monitoring wells will be filled with sand and capped prior to ZVI injection.

Following completion of the ZVI-PRB, the eight monitoring wells will be airlifted to remove the sand and redeveloped."

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

3. Based on Table 8 (Sampling Frequency and Analytes for EMP Monitoring Well Stations), geochemical analyses [e.g., total organic carbon (TOC), alkalinity, chloride, nitrate-nitrite as nitrogen, sulfate, methane, ethane, ethylene, phosphate, calcium, iron, potassium, manganese, magnesium, sodium, iron (3+), iron (2+), total dissolved solids (TDS), dissolved organic carbon (DOC), sulfide] will only be sampled at in-wall locations. As such, it is unclear why downgradient wells will not be monitored for geochemical analyses to evaluate the effectiveness of the ZVI-PRB. Revise the RADP to clarify why only the in-wall locations will be monitored for geochemical analyses.

Response: Agree

The purpose of the in-wall monitoring is to provide rapid evidence of the ZVI effectiveness in destroying VOCs and using the geochemical analyses to provide a direct evaluation on the health of the ZVI-PRB. For clarity, Section 5.1 will be revised as follows:

"... Station IDs, coordinates, and screen depths are provided in Table 6. The purpose of the in-wall monitoring is to provide rapid evidence of the ZVI effectiveness in destroying VOCs. In addition, the geochemical analyses proposed for in-wall monitoring wells will allow for evaluation of the reactions occurring between the contaminated groundwater and ZVI on the ZVI-PRB longevity related to possible precipitation, mineralization, and biofouling. The upgradient and downgradient monitoring well clusters will be analyzed for VOCs to assess the overall reduction in VOC mass in the plume over time. Because the downgradient monitoring wells are located in contaminated aquifer sediments it may be many years before evidence of VOC reduction is observed. The in-wall monitoring well will be sampled bi-monthly . . ."

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

Comments Received May 31, 2019

SPECIFIC COMMENTS

1. **Section 1.2, General Description and History of the PAGW OU, Page 2 of 52:** Section 1.2 states, "Tetrachloroethylene (PCE) and cis-1,2-dichloroethylene (cis-DCE) plumes present in the UAZ and LAZ are contained within the TCE plume area;" however, the RADP does not include a figure showing the locations of the PCE and cis-DCE plumes within the trichloroethylene (TCE) plume areas. For transparency and completeness, revise the RADP to include a figure showing the locations of the PCE and cis-DCE plumes within the TCE plume areas.

Response: Clarification

The Sampling and Analysis Plan Addendum for PAGW OU (SRNS-RP-2018-00261) provides detail on the nature and extent of all the VOCs, demonstrating the TCE footprint encompasses the PCE and cis-1,2-DCE plumes shown in Figures 17-20 of that document. PCE and cis-DCE are cVOC's that will be destroyed by the removal action along with the TCE. A reference to the Sampling and Analysis Plan Addendum will be added as follows:

Section 1.2, Final Paragraph:

"... Tetrachloroethylene (PCE) and cis-1,2-dichloroethylene (cis-DCE) plumes present in the UAZ and LAZ are contained within the TCE plume area as described and shown in the Sampling and Analysis Plan Addendum (SRNS 2018b). The source area ..."

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

2. **Section 2.7, Surveys, Page 12 of 52:** Section 2.7 indicates that a lay-out survey that identifies possible subsurface interferences will be prepared for each injection and monitoring well location; however, additional details regarding this lay-out survey are not provided and/or referenced in the RADP. In addition, it is unclear why the lay-out survey has not already been conducted given that subsurface interferences can directly impact the effectiveness of the ZVI-PRB. Revise Section 2.7 to provide additional details regarding the lay-out survey. In addition, clarify why the lay-out survey has not already been conducted given that subsurface interferences can directly impact the effectiveness of the ZVI-PRB.

Response: Agree

Lay-out surveys, including ground-penetrating radar, are required to be performed on site before all drilling activities to determine if shallow interferences are present that may cause safety issues with the activity. In addition, prior to the design phase of the removal action, the proposed PRB area was surveyed and site drawings were used to verify that no subsurface interferences would impact the ZVI-PRB. For clarity, Section 2.7 will be revised as follows:

"Prior to the design phase of the removal action, the proposed PRB area was surveyed and site drawings were used to verify that no subsurface interferences would impact the ZVI-PRB. In addition to the figures and tables . . . ."

Comments Received May 31, 2019

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

3. **Section 4.4, Waste Disposal and Transport, Page 16 of 52:** Section 4.4 states, "Based on process knowledge and TCLP [*Toxicity* Characteristic Leaching Procedure] results provided by the ZVI vendor, no hazardous waste will be generated;" but information to substantiate this statement is not provided and/or referenced. Revise Section 4.4 to provide information to substantiate that no hazardous waste will be generated as part of the ZVI process.

Response: Clarification

Waste iron filings that remain after decanting the washout fluid is not characteristically hazardous waste, as indicated by the safety data sheet provided by the ZVI vendor (attached). As a result, based on the process knowledge of the construction materials, there is no hazardous waste constituents present within the raw materials that are being utilized for construction of the PRB that would result in a RCRA characteristic hazardous waste. For clarity, the first paragraph of Section 4.4 will be revised as follows:

"... Based on process knowledge ~~and TCLP results~~ <u>of the PRB construction along with the iron filing safety data sheet provided by the subcontractor,</u> ~~provided by the ZVI vendor,~~ no hazardous waste will be generated."

Responsible Party: Joseph Burch, (803) 952-6660, joseph.burch@srs.gov

4. **Figure 10, TCE Plume Cross-Section Perpendicular to Groundwater Flow Direction and Figure 11, TCE Plume Cross-Section with ZVI-PRB Injection Wells, Pages 35 and 37 of 52:** The path of the bisects/trend-lines used for the cross-sections presented in Figures 10 and 11 is not shown on Figure 9, Design Data Acquisition Plan Locations. Revise Figure 9 to include the bisects/trend-lines used for the cross-sections presented in Figures 10 and 11.

Response: Agree

The UAZ TCE plume delineation was added to Figure 9 (attached) as suggested.

Responsible Party: Adam Willey, (803) 952-8738, adam.willey@srs.gov

SAFETY DATA SHEET

Peerless Metal Powders & Abrasive LLC
124 S. Military St.
Detroit, MI 48209
USA

February 19, 2016

1. Product and Company Identification

Product Name: Steel Shot, Steel Grit, GN Grit, Flex Shot, Ultra Soft Shot, Steel Aggregate, Cast Iron Aggregate, Steel Ballast

Manufacturer: Peerless Metal Powders & Abrasive L.L.C., 124 S. Military St., Detroit, MI 48209

Phone (313) 841-5400 Fax (313) 841-0240

Emergency Phones (313) 841-5400 primary, (888) 989-3647 secondary

2. Composition / Information on Ingredients

Steel and Iron particles / Principle constituents

C	0.01 – 3.0%	Mn	0.10 – 1.0%
Si	0.2 – 3.0%	S	0.1% max
P	0.1% max	Fe	Balance by subtraction

3. Hazards

Peerless currently knows no risk to people or the environment from this class of product.

If dust is generated during the use of handling of these materials, extra precaution for eye protection (eye glasses or goggles), skin (gloves and long sleeves) and respiration (particle dust mask) are recommended. Spills of these materials may present a slip/fall hazard.

4. First-Aid Measures

Eyes: Wash/rinse with clean water or sterile eye wash solution. If irritation persists, consult physician.

Skin: Wash with soap and water. If cut or if irritation persists, consult a physician.

Inhalation: Remove to fresh air, give water for cough and consult a physician.

Ingestion: Rinse out mouth and consult a physician.

5. Fire Fighting Measures

These materials, as coarse particles, are non-flammable and do not react with water or other materials used for extinguishing fire. Fine metal dust may pose a risk of fire or explosion if accumulated, mixed and confined with an ignition source. When handling fine particles generated from this material, avoid creating dust clouds and ignition sources.

In the event of powder metal fire, avoid scattering material. CO_2 is suitable for extinguishing.

6. Accidental Release Measures

Sweep up with broom and/or flat scoop shovel. Loose material can create a slip and fall hazard. Avoid creating dust clouds. Wear eye protection, dust mask and gloves while working with this material.

7. Handling and Storage

Use proper capacity device when moving packaged material (pallet, drum, pail or bulk bag). Store in dry place. Do not stack in unstable manner. Avoid rupturing container by piercing or dropping.

8. Exposure Controls / Personal Protection

Use adequate local exhaust ventilation if dusty conditions are created while handling these products. A particulate dust mask may also be appropriate to supplement the ventilation system. Eye protection in the form of glasses with side shields, fitted goggles and/or face shields are indicated for handling these materials. Long sleeves and gloves will reduce the possibility of skin contact and abrasion while handling these materials.

9. Physical and Chemical Properties

Form: Solid metallic particles	Solubility in water: very low - may form rust
Odor: None	Non-flammable, except as fine dust
Bulk Density: 2.4 to 4.8 tonne/m^3	Color: various - grey, lustrous metallic, black
Specific Density: 6.8 to 7.8 tonne/m^3	Vapor pressure: Very low at room temperature
Melting Temperature: 1200° to 1500°C	

10. Stability and Reactivity

Stable under normal conditions. These products do not present danger for hazardous reactions.

11. Toxicological Information

No known severe toxicity. No known local effects. Nuisance dust exposure may cause eye and/or throat irritation.

12. Ecological Information

Non-hazardous.

13. Disposal

May be disposed as non-hazardous solid waste in compliance with local regulations. Special conditions may apply if mixed with other material.

14. Transportation

Not regulated. Comply with normal shipping methods. Material should be kept dry.

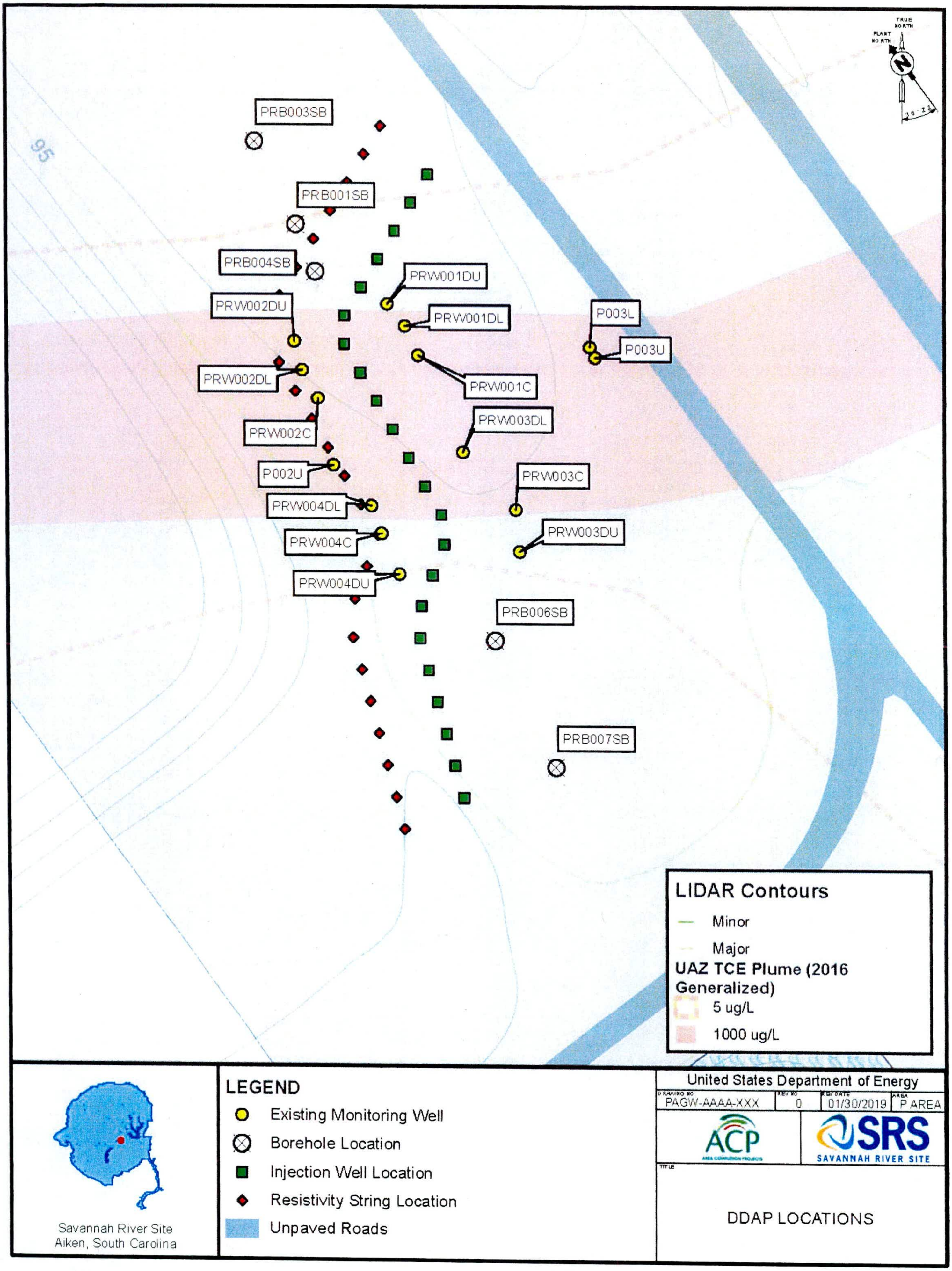
15 Regulatory Information

None apply.

16. Other Information

Revision: 0. Issue date: June 3, 2015. Djc

Revision: 1. Revised product names and corrected minor punctuation January 21, 2016. djc



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PRW003DL
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P002U
PRW003C
PRW004DL
PRW003DU
PRW004C
PRW004DU
PRB006SB
PRB007SB
LIDAR Contours
Minor
Major
UAZ TCE Plume (2016 Generalized)
5 ug/L
1000 ug/L
Savannah River Site
Aiken, South Carolina
LEGEND
Existing Monitoring Well
Borehole Location
Injection Well Location
Resistivity String Location
Unpaved Roads
United States Department of Energy
PAGW-AAAA-XXX
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P AREA
ACP
SRS
SAVANNAH RIVER SITE
DDAP LOCATIONS